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ABSTRACT

Noting that work is partly a social activity, and that workers' psychological and emotional needs influence their productivity, this paper explores avenues for improving human-robot cooperation and for enhancing worker satisfaction in the environment of flexible automation. The first section of the paper offers a brief overview of the worker-machine relationship, discussing several assumptions that have lead to inaccurate research conclusions and poor communication between author and reader. The major section of the paper addresses the critical impact of flexible automation on human workers and on organizations, specifically the areas of (1) worker isolation from other humans; (2) worker communication relationships with robots; (3) worker stress; (4) supervision, control, and information transmission in the computer controlled factory; and (5) human self-esteem vis-a-vis computer controlled robots. (FL)

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DESIGNING A SOCIAL ENVIRONMENT FOR HUMAN-ROBOT COOPERATION

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Flexible automation, especially robotics, promises a new communication environment as well as changes in organizational behavior. The concept of "robot as colleague and, potentially, as supervisor" challenges conventional wisdom about personnel management and industrial relations. With an understanding that work is, at least in part, a social activity, and that workers' psychological/emotional needs impact on productivity, this paper explores avenues for maximizing human-robot cooperation and for enhancing worker satisfaction in the environment of flexible automation.

INTRODUCTION

The manner in which workers relate to their tools is not a new theme for study. But tools change, and such changes affect the user and the culture.

In the early days of agriculture, man pushed plow. Man and plow were one. Man provided brain and brawn. Then horsepower (or oxpower) replaced manpower. Man became a driver and could build a "talking," affectionate relationship with his "beast of burden." The farmer's tasks and relationships changed again as he became the tractor's mechanic. But still he provided brainpower as he steered his machine. Now we plan for agricultural robots which plow the land, drop the seed, cover the furrow, water the plant, and pick the crop—unaided by humans.

The dramatic change in tools (flexible automation) provides a first reason for examining human-robot relationships. A second motivation is that employees insist on athropomorphizing their newest tool—the robot.

When asked how they learned about robots, workers frequently refer to movies like "Star Wars" and similar science fantasy programs. A recent movie advertisement reads ominously

CS 204 HHS

On Saturn 3
The ultimate
man-made robot
possesses
everything...
Violence, Evil, Lust.

Similarly, children learn "robotics" from their little android toys. A cartoon shows a small boy addressing three little humanoid robots. He commands, "Clean up my room, squad six!"

It is not surprising then to read that "workers on each shift named the robot and endowed it with human qualities."[1]

ASSUMPTIONS AND FRAMEWORK

Before focusing on the major issues of this paper, it is useful to look briefly at several parameters which affect the theories of worker-machine relationships and which are often overlooked by authors in this field. Unstated assumptions can lead to inaccurate research conclusions and dysfunctional communication between author and reader.

One Robot Vs. Many

The impact of one or two robots in a large production setting may be significant, but it is not the same as the "factory of the future" (FOF) built around maximum computer integrated production. The difference is not one of degree. It is a difference in kind. The first simply involves a special tool in a traditional environment. The FOF involves computer controlled design, inventory, traffic, assembly, quality control, packaging, and, perhaps, shipping. The former has primary human control. The latter requires minimum human interference except for support personnel.

As we explore human factors in manufacturing, we will need always to be clear whether we are talking about an occasional robot in a traditional setting or a computer integrated production facility.

Transition Workers Vs. New Workers

The problems facing workers in settings where robots are being introduced are often significantly different from the problems associated with employment in a setting where robots are well integrated. Researchers frequently confuse the stress of transition with whatever stress is associated with human-robot interaction.

Furthermore, new employees come to the job with expectations of work activity and work setting quite different from the expectations of older workers. Hence, it is easy to confuse the impact of flexible automation with the impact of unmet expectations.

Training Vs. Socialization

The cry for retraining has become a cliché. Teaching technical skills is the easiest part of helping workers adapt to new work environments. The social-emotional impact is the neglected aspect and requires special preparation.

Child development experts understand that pre-school and early childhood education serve primarily to socialize children into the culture. To a large extent university education serves to teach behavior styles (role behavior) as much as it serves to provide knowledge and skills. Industrial managers, labor union experts, as well as adult education specialists often do not value the personal "retraining" needed to adapt to a modified job setting or to a new job. Consequently, the call for retraining frequently misses the real need for resocialization. This paper points primarily to socio-emotional needs rather than information and skill needs.

CRITICAL IMPACTS OF FLEXIBLE AUTOMATION ON HUMAN WORKERS AND ON ORGANIZATIONS.

> "An organization is a stable system of individuals who work together to achieve, through a hierarchy of ranks and division of labor, common goals....Organizational structure lends predictability and stability to human communication, and thus facilitates the accomplishment of administrative tasks."2

While the overwhelming need for stability may sometimes be counter-

productive to achieving creativity, it is this constant effort toward homeostasis that makes the work of organizations possible. Norbert Wiener in Cybernetics makes the analogy to physiological phenomena.

> The conditions under which life, especially healthy life, can continue in the higher animals are quite narrow. A variation of one-half degree centigrade in the body temperature is generally a sign of illness...[3]

In an organism as well as in an organization, almost anything we do to one component has impact on other components. Any psychosomatic or pathological disruption can cause disaster. A communication disruption in the human body can be seen as a traffic problem of the nervous system. A similar communication traffic problem in a production organization can similarly cause organizational illness or death.

The goals of individuals may not be in harmony with the goals of the organization thus threatening organizational stability. Indeed, in western countries, especially the United States, discipline and dependence are less valued than in Japan, and independence has higher cultural value. Thus organizational homeostasis is constantly threatened.

Each introduction of a new component (new machinery, for example) affects other components. One of the important affected components is the human worker, and this component is least controllable and most difficult to "adjust." Consequently it pays to examine the disruptive effects of flexible automation and to see how homeostasis can be reestablished.

Worker Isolation From Other Humans

For most employees work is largely a social activity. One returns from work to report to ones spouse not that, "I made 37 widgets today," nor that, "I enjoyed adjusting 18 fan belts." Rather one reports, "Did you know that Betty is pregnant again" and, "Our bowling team is number three in the league." The more boring the work, the more one hears of on-the-job teasing, practical jokes, and gossip.

The German design phenomenon, "bürolandschaft," introduced to the United States as "office landscaping," taught a great deal about office productivity. We learned that private offices are not always useful. In the noisy bustle of the open newsroom reporters chat and share ideas. In private cubicles or offices, they daydream. Similarly, research repeatedly shows that secretaries, engaged in boring work, increase their productivity if placed in open spaces with occasional distractions, disruptions, and opportunities to chat.

Productive communication diminishes with physical isolation. One research project demonstrated that "two people who are on the same floor, if separated by more than 25 yards, will rarely have any significant communication."[4] The geography of the work site clearly affects social and work related communication!

"Work deters alienation and isolation by fulfilling powerful socialization needs."[5] Evidence comes from researchers who evaluated the opportunity to work at home, using the computer as a link to the office. The isolation, say the researchers, frequently inspires requests to return to the work site. Comments include, "She missed her buddies at work..." and, "You bump into people at the coffee pot..." Professor Jack Niles of the University of Southern California points out that one loses a sense of community. People not in daily contact with others become narrowly concerned with their own wishes. They become antisocial.[6] One begins to see the motivation for organizational sabotage.

Whyte reports that in the industrial setting, increased automation decreased opportunities workers had to interact with their co-workers.[7] On the factory floor the introduction of robots leads to work cells. One worker may attend a cell or even several cells. Gone are the days of shoulder to shoulder work with ample social contact. Even in extremely noisy settings where conversation is difficult visual contact was continuous. It may be that the absence of visual contact is more isolating than the absence of verbal contact.

Interestingly, some workers report that speed and complexity of the new

machinery requires greater concentration, thus forbidding distractions and leading to even greater isolation.

Several antidotes come to mind. The obvious include fewer work hours and more coffee breaks. The former is almost inevitable, and the latter may not be cost effective. Less obvious solutions include access to radio (if such a distraction is appropriate) and computer link to other work stations.

There are those who argue that robots should, and will, become more "responsive" and in some ways provide the human partner more "interaction." The "interactive robot" as work and social partner is not as ludicrous as first appears if one remembers that most workers continue to anthropomorphize their robots and include the comraderie of R2D2 and similar friendly robots among their expectations.

A more realistic and helpful solution may lie in the relationship between on site production workers and visiting maintenance workers. Industrial planners continue to warn that cooperation between production workers and technical support personnel is necessary to keep automatic machinery in top working order and to catch potential breakdowns as early as possible. To encourage work cooperation management might consciously encourage social cooperation. One might view the maintenance technician or engineer like the good doctor with an understanding of science, and yet exhibiting a friendly bedside manner toward patient (robot) and family (production worker). Or the roving technician may be perceived as a "visitor" to diminish tedium and isolation. Certainly in earlier days the visiting repairman, salesman, and postal worker served similarly to reduce the isolation of the homebound housewife.

To encourage social and task cooperation between production and maintenance workers, management needs to watch for several potential pitfalls. The first is addressed directly by Argote, et al.

> If many robots were being placed on-line and the support personnel had great demands on their time, then we might find more conflict between support personnel and the operators.[8]

The second potential pitfall includes some critical labor relations issues which could lead to competition rather than cooperation and will need thoughtful attention by management. Howard writes

> These issues include jurisdictional lines between operators, maintenance personnel, and programmers; labor grades; pay scales; training...[9]

Worker Communication Relationships With Robots

Humans need to build relationships with elements of their environment. They love and hate each other, build incredibly close relationships to their plants and animals, name their boats and occasionally their automobiles, and praise and blame diverse machinery as though it were animate. If we know that humans need relationships, and that flexible automation leads to isolation from other humans, and that workers tend to anthropomorphize their robots, should we not expect that human workers will build special, perhaps predictable, relationships with their robots?

Unlike other tools, robots are "smart" machines. That means they have an on-board brain or are hooked to one. They frequently have sensors. Consequently, robots have the potential of "responsive" behavior. They can play games (and move their own pieces), talk and listen, make decisions, and, in a few cases, they are mobile.

Robots, then, because of their "responsive" abilities, and because of the expectations humans attribute to them, inspire something akin to interpersonal relationships. Relevant theory can be applied here. For example, robots inspire competitive feelings.

> By our second visit, workers seemed resigned to the fact that the robot would always be able to outproduce a human worker... Although objectively the operators controlled the robot and the two milling machines, they subjectively felt that there was competition between them and the machine.10

In this way robots can cause stress and test human self esteem; both are threats to organizational stability. These themes will be discussed in a later section. At issue here is the form in which humans and robots interact, and might interact to attain maximum cooperation.

While experts agree that at least two-thirds of human communication is nonverbal, we have not yet been able to teach robots the nuances of gesture, touch, distance, tone of voice, dress, and odor. We need to rely almost entirely on buzzers, lights, gauges, and spoken or written language. Of these options our culture values spoken language as the best communicator for friendship. Those of us who spend much time at meetings forget the importance of aural stimulation and spoken interaction.

Lin, et al. report on a new audio spectrum analyzer chip as well as other speech processing technology which is now commercially available and which increases many fold the potential recognition and speaking vocabularies of computers.[11] Robots have been programmed to call aloud when they need the help of a human operator. And robots at Stanford University have been taught to respond to the spoken commands of quadriplegics. By utilizing voice communication technology we develop a more human-friendly robot which is easier to use as a tool and easier to feel comfortable with.

Now that voice processing technology is adequate we must face the problem of language. Even programming has become confused because of the many computer languages available. Efforts are underway to have a single robot language so that programming can be codified and so that robots can more easily communicate with each other. Will the robot language be so "foreign" to the average user that the worker will become an outsider to robot communication? If workers are to be part of the robot communication newtwork, a user friendly language must be available.

At international conferences we tend to exchange ideas and feelings only with those who speak a language which is comfortable for us. Similarly, cooperative man-machine interface implies a language which is both functional and comfortable for the user. If the "responsive" robot can respond in the primary language of the user, we have at least the potential of a cooperative relationship.

Worker Stress

"Technostress" is not unlike other stress. It is, however, a response to specific stimuli which, if identified, can be altered or counterbalanced so as to minimize or alleviate the symptoms. By ignoring worker technostress one risks worker resistance, organizational instability, and disruption.

As previously suggested, a good deal of stress reflects a response to the insecurity of change. Workers in transition need lots of emotional support, recognition that they are in transition, and praise for adapting well.

In some instances where jobs are radically altered, it may be best to transfer employees to a totally new setting. In this way they can, more easily, develop new expectations without feeling that "my" job has been changed. A new employee in the altered position sees a modified job as a new job and has more flexible expectations.

Indiscriminate or excessive transferring, however, can also create stress and disatisfaction. Japan, whose factories are more automated than European or American plants, is reporting that

> the strains produced by large-scale automation are beginning to affect the style and substance of Japanese labor-management relations....[the workers'] lot is to endure the frequent job reassignments management impose on them. Some workers, complaining of psychological fatigue, have even quit...The psychological impact is far greater than outside observers imagine.[12]

Interestingly, some workers in jobs where flexible automation has been introduced report the kind of positive stress (rather than distress) associated with adventure. They welcome the break in tedium. Managers would be well to learn from such reports. In times of transition underscore the aspect of adventure and eliminate the fear of failure. Invite participation in a

"challenge with robotics."

Stress caused by competition with robotics has been identified earlier. This, too, may be a function of transition. Newer, younger workers, more comfortable with computers and their peripherals, such as robots, may accept as a matter of course that robots are stronger, faster, more accurate, and have greater endurance.

Stress related to isolation has been discussed in a different context. Clearly, management must make efforts to provide a sense of belonging and to integrate isolated workers into a communication network.

In many cases the introduction of flexible automation has confronted workers with more difficult tasks. They frequently report that relating to a complex and, incidentally, expensive robot rather than an inanimate part or a piece of bar stock, requires greater concentration and creates a sense of pressure. Historically industry, when recognizing high pressure jobs has provided added incentives (pay), frequent periods of rest and relaxation (R & R), and, as appropriate, has offered the opportunity of job rotation.

The introduction of robots may alter activities as well as interactions.[13] For example, the task of watching may be more stressful than tasks requiring lifting and placing. In such cases, assignment of multiple tasks and opportunity to walk from location to location alleviates the tension. Interestingly, workers often report that the task of watching machinery produces boredom—a cause of extreme distress. Boredom is not a new problem to industry and the literature is filled with prescriptions.

Finally, robots are frequently perceived as unsafe. While such fear can lead to stress, it should not necessarily be treated as a psychological problem. Instead, every possible safety feature should be built into robots so that their reputation precludes fear.

Supervision, Control, and Information Transmittal in the Computer Controlled Factory

Norbert Wiener in his fascinating book Cybernetics points out that the techniques of transmitting information (control) and measuring information (feedback) are of equal interest to the engineer, the physiologist, the psychologist, and the sociologist.[14] Feedback is a concept generally understood by communication theorists. More original is the other half of Wiener's thesis identified in his subtitle, "Control and Communication in the Animal and the Machine." He brings the theories of control and communication together when he describes an information source sending a message which causes something to happen at the receiving end. From the perspective of communication engineering

> This signal may be the tap of a key, to be reproduced as the tap of a telegraph receiver at the other end, or it may be a sound transmitted and received through the apparatus of a telephone; or it may be the turn of a ship's wheel, received as the angular position of the rudder.[15]

In order to explore the concept of supervision and its role in the modern factory we adapt some of Wiener's control theory. Supervision, in a superficial sense, may be seen as the transmittal of information in order to cause an effect. Quality supervision includes the measurement of the information transmittal (feedback).

In the theoretical factory of the future production will be almost entirely computer controlled. Hence, a central computer (supervisor) will send instructions to inventory and to diverse work cells to control the behavior of the automatic machinery. Good engineering provides for adequate feedback mechanisms so that local computers can report to the "supervisor" about the progress and quality of the product and about the status of each machine. Decisions will be made by the supervising computer. More realistically, in the intermediate, future humans will be part of the system. At minimum, one sees maintenance workers at terminals monitoring the status of each machine.

The picture painted here raises some interesting, even critical, questions. If CAD/CAM implies a great computer controlled information processing network, one wants to inquire where and how humans enter that system.

If one is not seduced by science fantasy, one must assume that the initial decision making and major programming falls to a master human—or a group. After that, however, one sees the computer controlling the human on-line workers.

Telephone operators have been expressing anger that the computer monitors the quantity and quality of work—and reports the results to human bosses.

> For the telephone industry, some experts said, the computer speeds work that employees are expected to do and allows it to be carefully monitored. In effect, the computer becomes the foreman.[15]

Efforts to impose and monitor work speed-ups are not new. Hitherto, however, the control and feedback mechanisms were human.

If we clearly see robots as computer peripherals—machines with "brains"—they will have access to information from their own sensing mechanisms and programs, they will be linked to the organization's information network, and they will be able to process information. By sharing such information appropriately they will be directing or modifying a human operator's behavior. They will have at least some degree of control. Certainly, from a work point of view, they will become at least a partner—a colleague—if not a foreman.

The implications are enormous. Western literature, reflecting western culture, has historically expressed fear of being dominated by machines. The picture painted here invites resentment and resistance. From a cultural point of view, it would be better to eliminate humans from the production system than to let them be excessively supervised by robots. In the short and intermediate term, it would be well to plan for human-robot cooperation, even at the risk of limiting robot intelligence, until such a time when humans can be withdrawn from the production system except as designers, monitors, and decision makers.

Currently supervisors have, on average, a control span of six persons. If robots are introduced at each level in the organizational hierarchy, will they be included as supervisees? Will, on the average, a leader supervise perhaps 4 humans and 2 robots or 5 robots and one human? Will robots supervise, perhaps, 3 robots and three humans? One would hope that, at least for the present, robots will be perceived as machines rather than humanoids. However, because the new machines are extremely complex and require special attention, one may need to modify supervisor-supervisee ratios to account for the difficulty of tasks. Historically, more direct supervision has been available to those in intellecually or psychologically complex jobs. Indeed, as robots become more commonplace, supervisor-supervisee ratios may be modified until one has small teams or even a two-person "buddy" system. Organizational planners should be open to such real options.

Finally, as production systems become more automated, the number of workers at a single work site will diminish. Colston is only one of many who sees this as a boon to management.

> I would not like to...handle a factory which employed 10,000 people on one site. I think 5, 6 or 700 people...is quite adequate...In this respect robots can be quite advantageous as...one can keep the number of people on one site down to a manageable number whilst having a viable output.[17]

Human Self Esteem Vis-a-vis Computer Controlled Robots

Industrial psychologists have long known that workers who feel confident and competent are more cooperative, more willing to risk, and more willing to support team goals than workers who feel inadequate, unnecessary, and/or oppressed.

However, Ayres and Miller write

> Whereas most technological developments before the twentieth century can be interpreted as extensions of purely physical abilities (strength, speed, power), developments in the twentieth century have increasingly shifted into the arena of control and information processing.[18]

Similarly, Chern observes that the industrial revolution involved the transfer

of physical skills from man to machine. "The second industrial revolution, now in its infancy, involves the transfer of intelligence from man to machine."[19] How then does one support human self-esteem when robots are stronger, faster, "smarter"—and sometimes "in charge."

Alienation stems primarily from a sense of powerlessness which means almost literally to be "out of control."

Since early in the first industrial revolution, workers have expressed fear of becoming a servant to machinery. Charlie Chaplin, as well as other social critics, mocked the power of machines.

And yet machinery does control our behavior. Industrial machinery, robots included, is not tolerant of disorder. Industrial robots, for example, do not function well unless parts are presented in a known sequence and position. Hence, workers complain of becoming "handmaidens" to machines—running their errands and fixing their environment.

Unfortunately, no easy solutions come to mind. By providing robots with greater flexibility, mobility, and sensing power one, of course, diminishes the need for "handmaidens." But in the process robots become "smarter" and acquire greater control.

One can advise about what should not be done. There is some danger that companies which mismatch machinery and humans will call a "shrink" to fix the people. Indeed, it is appropriate to beware efforts to modify the design of future humans to adapt to machines. Glimpses at such efforts are beginning to creep into the human relations literature. Will we have a new science of "ethnonomics," to replace ergonomics?

For lack of useful suggestions to enhance self-esteem in the evolving computer integrated factory one looks to other aspects of life. Job enrichment can include cultural opportunities such as company drama societies, music associations, poetry clubs, and dance recitals. Job enrichment can praise the employees' intelligence by providing lectures, book clubs, and adult education in the humanities, the social sciences, as well as occupational training.

Finally, one must praise the concept of quality circles. Even if they were less productive than they are, such planning groups make employees feel respected and needed—even smart. In an ever more alienating work setting, purposeful efforts must be made to help workers feel like fully functioning and useful human beings.

CONCLUSION

Anyone can "tell it like it is." What is enormously more difficult is to tell it like it should be. This paper tries to provide a theoretical framework for "telling it like it is" and for developing some recommendations for those planners concerned with human factors in present and future manufacturing settings.

Many issues have not been approached. Matters concerning job displacement, job security, pay, and labor unions have been left for others. Furthermore, it is assumed that every manager now knows that workers must be involved in the planning for new flexible automation. In this context one can only underscore the wise advice that

> Some feedback mechanism to monitor communication effectiveness in introducing this technology is necessary. Our study showed a discrepancy between what management was trying to communicate to workers and what the workers actually received.[20]

Nor should employees be over-prepared. By focusing on potential problems, managers can instill fear and a self-fulfilling prophecy of doom.

Recommended here is that planners have a clear understanding of human responses to technological changes: a clear vision in contrast to traditional industrial relations clichés. Planners tend to confuse the intermediate term problems of single robot introduction with the long term problems of computer integrated manufacturing.

Planners tend to confuse the ongoing problems of transition with authentic cultural change brought on by new forms of human-machine relationships. Planners tend to confuse technical retraining with the need to meet

the changing emotional needs of workers.

A look at history reminds us of the major storms brought on by radical changes in manufacturing—nationwide strikes, destruction of machinery, and physical violence. Organizational homeostasis is very delicate. Careful, thoughtful, sensitive planning can minimize the inevitable disruption of organizational stability.

Worker isolation from other humans, technostress, and attacks on employee self esteem are inevitable. Judicious employee transfers (job exchange) are at one end of the "solution spectrum." Toward the other end one sees complex solutions including job enrichment and even life enrichment.

To some extent, the manufacturing worker's relationship with robots (the new tool) may lead to new forms of alienation or, instead, may partially cope with the problems of isolation and self esteem. Ultimately, the design of the tool (robot) affects the individual's relationship with that tool. In a sense, then, one can anticipate and even design relationships.

The evolving theory of supervision and control in the FOF needs greater attention. An organization in which much of the communication and decision making involves computers and their robot peripherals is radically new. Herein lies a field of study for industrial relations professionals.

AFTERWORD

A recent cartoon shows a robed priest in his pulpit, hands folded, eyes toward heaven, praying "...and ease us, O Lord, into the high tech era as painlessly as possible." Amen!

REFERENCES

[1]Argote, L., Goodman, P.S., Schkade, D. "The Human Side of Robotics: How Workers React to a Robot." Sloan Management Review, Vol. 24, No. 3, pp. 31-41 (Spring 1983), p. 33.

[2]Rogers, E.M., and Agarwala-Rogers, R. Communication in Organizations. Collier Macmillan, London, 1976, p. 6.

[3]Wiener, N. Cybernetics. M.I.T. Press, Cambridge, 1961, p. 114.

[4]Rogers, p. 102.

[5]Jacobs, Bruce A. "Humanizing the Electronic Office." Industry Week, (1981).

[6]Ibid.

[7]Argote, p. 32.

[8]Ibid., p. 38.

[9]Howard, J. "Focus on the Human Factors in Applying Robotic Systems." Robotics Today, pp. 32-34 (December 1982), p. 34.

[10]Argote, p. 37.

[11]Lin, L.T., Tseng, H.F., Cox, D.B., Viglione, S.S., Conrad, D.P., Runge, R.G. "A Monolithic Audio Spectrum Analyzer." IEEE Transactions on Acoustics, Speech, and Signal Processing (February 1983).

[12]Saga, I. "Japan's Robots Produce Problems for Workers." The Wall Street Journal, p. 24 (February 28, 1983).

[13]Ayres, R.U., and Miller, S.M. Robotics Applications & Social Implications. Ballinger, Cambridge, 1983, p. 95.

[14]Wiener, p. vii

[15]Ibid., p. 39.

[16]Serrin, W. "Technology Takes Toll on Operators." Minneapolis Tribune, pp. 1D & 10D (November 27, 1983), p. 10D.

[17]"No Magic Formula for Good Industrial Relations." The Industrial Robot, Vol. 10, No. 2, pp. 124-125 (June 1983), p. 124.

[18]Ayres, p. 127.

[19]"Robots Join the Labor Force." Business Week, pp. 62-76 (June 9, 1980), p. 73.

[20]Argote, p. 39.